Provenance Trials of *Juglans mandshurica*

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Abstract The data of provenance trial on *Juglans mandshurica* young tree were investigated and studied from different provenance. Analysis methods of variance and correlation analysis were used to analyze these data. The following conclusions were obtained: (1) The difference of growth characters of *Juglans mandshurica* is relatively significant among provenances; (2) The result of first trial has indicated that *Julans mandshurica* growth trend expresses two-way gradual change trend with different longitude and latitude, but the second trial has no obvious gradual change trend. Height of *Juglans mandshurica* is negatively correlated with elevation; (3) The provenance of Shulan, Mao'ershan and Baishishan were selected as superior provenance of afforestational seeds for Mao'ershan and its brink region.

Key words: *Juglans mandshurica*, Provenance, Geographic variation, Provenance selection

Introduction

The research of provenance is not only the means of improving afforestational forestry but also is necessary base for other breeding system. Every country has paid universal attention to this way. IUFRO has also worked out the standardized rules of provenance trials to direct different country's provenance work.

Julagns mandshurica is mainly dispersed in the Xing An Mountains, Zhangguangcai Mountains, Changbaishan mountains and eastern mountain of Liaoning province. Its timber is fine and texture is hard and close. Its veins are straight and beautiful. It is precious timber and economic tree species. At present, *Juglans mandshurica* has won initial success from original wild condition to afforestational trial. In the near future, extensive afforestation is used to spread out in vast areas of northeastern China.

Material and Methods

Methods of trials

Trial fields have been established in Mao'ershan forest farm of Northeast Forestry University. Geographic coordinate is north latitude 45°20', east longitude 127°34', elevation 300 meters. Trial fields are secondary forests formed in felling land about wild forest of broad-leaf Korean pine. There were eight provenances in the first trial in 1985, and twenty provenances in the second trial in 1990. First trial provenance include Kuandian in Liaoning Province, Linjiang, Wangqing, Shulan in Jilin Province, Dongfanghong, Huanan,

Mao'ershan, Dailing in Heilongjiang province. This trial was designed as randomized complete block, 5 times replicates. 30 trees were planted as two rows per plot. There are twenty provenances in the second trial. They are Kuandian, Benxi, and Xinbin in Liaoning Province; Linjiang, Lushuihe, Baishishan, Wangqing, and Shulan in Jilin Province, Wuchang, Binxian, Mao'ershan, Muling, Dongjingcheng, Huanan, Qinghe, Liangshui, Tieli, Meixi, Suiling in Heilongjiang province. This trial used randomized complete block design, 8 times replicates, and 24 trees in every small plot arranged as four rows.

In spring of 1997, height, diameter at breast height, and tree crown diameter were investigated. There were 10 plants per plot in the first trial. Height, collar diameter were investigated. There were ten plants per plot in the second trial.

Statistical method

Firstly, two-way analysis of variance was used for analyzing significance difference of tree growth characters among different provenances. The mathematical model for analysis of variance is:

$$x_{ij} = u + \alpha_i + \beta_j + \varepsilon_{ij}$$

where:

u is character's overall mean,

α_i is the i-th block's effect,

β_j is the j-th provenance's effect,

ε_{ij} is random error,

x_{ij} is the observation of j-th provenance within the i-

th block 。

Then the simple correlation about growth characters, longitude, latitude, and climatic factors were computed. The trend surface method was used to study variation rules of growth characters along with longitude and latitude. The first step is to fit quadratic duality equation:

$$y=b_0+b_1x_1+b_2x_2+b_3x_{12}+b_4x_{22}+b_5x_1x_2$$

where: y is height, diameter at breast height, or diameter of tree crown:

x_1 is the longitude; x_2 is the latitude: b is regression coefficient

The second step is to select the important independent variables using setpwise regression, and use selected variables to establish regression equations. The third step is to use these equations for drawing trend surface chart and contour so as to study variation rules of growth characters with different latitude and longitude.

Results and Analysis

Genetic variation among provenance

The two-way analysis of variance for *Juglans mandshurica*'s growth characters were listed from Table 1 to Table 5.

Table 1. The analysis of variance for tree height in the first trial

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F value	Significance level
Between provenance	7	17.205	1.564	3.477**	0.0037
Between blocks	4	14.237	3.557	7.913**	0.0002
Error	28	12.595	0.450		
Total	39	44.037			

Table 2. The analysis of variance for diameter of breast tree height in the first trial

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F value	Significance level
Between provenance	7	16.998	1.545	3.454**	0.0039
Between blocks	4	14.035	3.509	7.844**	0.0002
Error	28	12.526	0.447		
Total	39	43.559			

Table 3. The analysis of variance for diameter of tree crown in the first trial

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F value	Significance level
Between provenance	7	1.606	0.145	1.116	0.3860
Between blocks	4	0.874	0.718	1.670	0.1849
Error	28	3.664	0.131		
Total	39	6.144			

Table 4. The analysis of variance for height in the second trial

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F value	Significance level
Between provenance	7	3.443	0.156	1.370	0.1702
Between blocks	4	1.333	0.445	3.904**	0.0732
Error	28	6.491	0.114		
Total	39	11.257			

Table 5. The analysis of variance for collar diameter in the second trial

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F value	Significance level
Between provenance	7	17.205	1.564	3.477**	0.0037
Between blocks	4	14.237	3.559	7.913**	0.0002
Error	28	12.595	0.450		
Total	39	44.037			

Note: **--difference is high significant in the above Table.

The above results showed that the difference of diameter at breast height and height growth is significant among different provenance in the first. The difference of the collar diameter is not significant in the second.

Geographical variation rules of growth character

By process of a long-term evolution and natural selection, many forest species have showed certainly gradual changes along with different longitude, latitude and elevation. We adopted mathematical statistics method to study *Juglans mandshurica*'s gradual change law.

Firstly, trend surface plotting was used to analyze combined variation trend of tree height and diameter at breast height along with different longitude and latitude. For the first trial, duality and quadratic multinomial regression equations were selected by stepwise regression, and listed in Table 6. We can see that this regression relationships reach significant level, so we draw

the trend surface plots and contours for the height and diameter at breast height in Fig. 1 and Fig. 2. The results show that the tree height and diameter's geographical variation is approximately alike. But, there is a region. The growth speed of tree is faster from in this region. This region is taken as center. Furthermore, growth speed is gradually slow in the northwest and southeast.

Table 6. The regression equation of trend surface plotting

Regressions	Fvalue	Rsquared
$H=253.7640 - 3.7615x_1 - 0.1165x_{22} + 0.0812x_1x_2$	58.89**	0.9833
$D=227.5436+5.5470x_1 - 5.4033x_2 - 0.0502x_1^2 - 0.1746x_2^2 + 0.1634x^1x^2$	533.58*	0.9996

Note: **--difference is high significant in the above Table.
  * --difference is significant.

Table 7. L.S.D test for the tree height and diameter at breast height of Juglans mandshurica's provenance

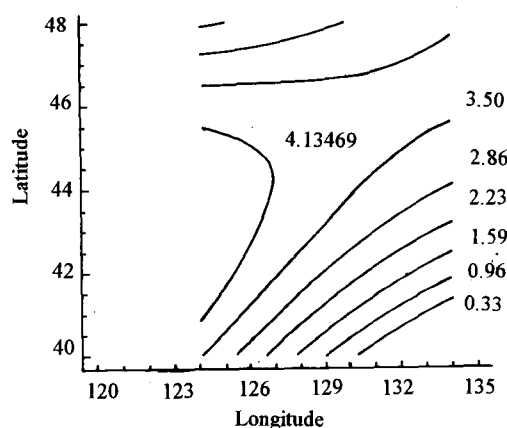|	The first provenance trial				The second provenance trial					
Provenance	height (m)	LSD(5%)	Provenance	DBH* (cm)	LSD(5%)	Provenance	height (m)	LSD(5%)	Provenance	Collar diameter	LSD(5%)
hulan	4.17		Shulan	4.41		Kuandian	1.70		Bashishan	2.76	
Maoershan	3.88		Maoershan	4.19		Suiling	1.69		Qinghe	2.71	
Kuandian	3.72		Huanan	4.15		Baishishan	1.61		Benxi	2.68	
Huanan	3.69		Dongfanghong	3.73		Qinghe	1.60		Muling	2.62	
Dongfanghong	3.61		Linjiang	3.57		Benxi	1.59		Maoershan	3.59	
Wangqing	3.42		Wangqing	3.57		Dongjingcheng	1.58		Wangqing	2.57	
Linjiang	3.39		Kuandian	3.56		Mao'ershan	1.55		Tiedi	2.57	
Dailinng	3.27		Dailing	3.41		Wangqing	1.54		Suiling	2.54	
						Tieli	1.49		Dongjingcheng	2.54	
						Wuchang	1.48		Binxian	2.38	
						Shulan	1.45		Liangshui	2.29	
						Linjiang	1.44		Linjiang	2.28	
						Binxian	1.44		Kuandian	2.27	
						Lushuihe	1.40		Shulan	2.17	
						Muling	1.38		LUshuihe	2.13	
						Langshui	1.33		Bajiazi	2.12	
						Meixi	1.27		Wuchang	2.02	
						Xinbin	1.12		Meixi	1.92	
						Huanan	1.09		Huanan	1.83	

Note: DBH* stand for diameter at breast height

Fig. 1 The contour plot of the provenance height for *Juglance mandshurica*

For the second provenance trial, all of the regression equations can not reach significant level after stepwise regression. Furthermore, the correlation coefficients between any traits and longitude, latitudes can't reach significant level. This showed that the tree height and collar diameter have no obviously change at the horizontal level in juvenile age, but showed random variation's model.

The variation rules of traits in the direction of elevation were determined by correlation analysis. We get rid of some outliners in the course of analysis. The correlation coefficient between tree height and elevation is -0.8325*, the coefficient between diameter at breast height and elevation is -0.8514* in the first trial. The height and diameter's correlation with elevation is -0.7716* and -0.6888* respectively in the second trial.

All of these reached the significant level and all of the correlation coefficients are negative, these means that the lower the elevation is, the better the growth of tree is.
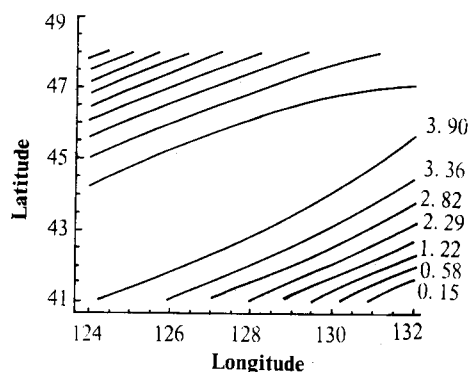

Fig. 2. The contour plot of the provenance diameter for Jug-lance *mandshurica*

Superior Provenance's Selection

The multiple range compression(L.S.D test) were made for the traits with significant difference, so as to provide basis for selection the best provenance for Maoershan and its brink region. The results were listed in Table 7.

We can see from Table 7 that the tree height growth of Shulan, Mao'ershan and Kuandian provenance express well in the first trial. The difference value of height both Shulan and Mao'ershan is not significant; but their difference value is all significantly higher than Shulan and Dailing's provenance, and is higher 27.5% and 14.3% than that of the average of all provenances and the worst provenance (Dailing)respectively. The

DBH of Shulan provenance is higher 15.2% and 29.1% than that of the average of all provenances and the worst provenance (Dailing). For the second provenance trial, Baishishan and Qinghe express well in growth of tree height and collar diameter. The difference of hieght growth in Kuandian is evindec; it is higher 46.6% and 16.5% than that of slowest provenance and the mean of all provenance respectively. The difference value of collar diameter of Baishishan is higher 50.6% and 18.6% respectively than that of the worst provenance (Huanan) and means value of provenance. So we think that Shulan, Mao ershan, Baishishan and Qinghe is the superior provenance to Maoershan and its neighborhood.

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